

REMARKS

Claims 16 and 21 are all the claims pending in the application.

Claims 16 and 21 have been rejected under 35 U.S.C. § 103(a) as obvious over Farid et al '529 in view of Harada et al '032 and Swainson et al '861.

Applicants submit that the cited documents do not disclose or render obvious the subject matter of the present claims and, accordingly, request withdrawal of this rejection.

Applicants set forth a detailed discussion of these three references in the amendment Under 37 C.F.R. § 1.116 filed on March 22, 2007, and continue to rely on that discussion.

By way of review, the present invention is directed to a method for inducing a non-resonant two-photon absorption, which comprises irradiating a non-resonant two-photon absorbing material comprising an oxonol dye undergoing a non-resonant two-photon absorption with a laser ray having a wavelength longer than the linear absorption band of the dye and present in the range of 400 to 1,000 nm to induce a two-photon absorption.

The two-photon absorption cross-sections of the compounds falling within the scope of the present claims are large. Among the exemplary oxonol compounds disclosed in the present specification, even the compound having the smallest two-photon absorption cross-section, namely, compound D-192, has an area of 1,200 GM. See Table 1 at pages 77 to 78 of the present specification. A compound absorbing two photons with greater than 71,000 GM, particularly greater than 10,000 GM, is rarely found.

In essence, the Examiner states that Farid et al disclose a composition comprising an oxonol dye PS 31 (shown in Table I), a binder, a monomer, an inhibitor and an activator. The Examiner states that dye PS 31 has an absorption maximum of 453 nm. The Examiner points out

that Farid et al disclose other sensitizers, such as cyanine dyes PS 1 to PS 2, styryl dyes PS 13 to PS 20, xanthene dyes PS 32 and PS 33, as well as merocyanine dyes, hemioxonol dyes and hemicyanine dyes.

The Examiner states that Harada et al disclose the curing of a photopolymerizable composition using a two-photon process. The Examiner states that the light is an ultrashort pulse from a Ti:Sapphire, which emits a pulse of 100-300 fs pulse at a wavelength within the range of 700-900 nm.

The Examiner further states that Swainson et al disclose that the use of two-photon processes is old and well known in the imaging arts. The Examiner states that in the embodiments of Class I, Group 2 (which relate to simultaneous multiphoton absorption systems), two photons of the same wavelength are used to cause the photoreaction. The energy difference between the two states is greater than the energy of a single photon, but equal or less than twice the energy of the photon.

The Examiner states that Swainson et al disclose that the starting point for a two-photon process is a material having known one-photon photoresponsive properties. See col. 2, lines 39-46.

The Examiner states that Example 3 of Swainson et al is a photopolymerization system that includes the xanthene dye sensitizer eosin Y, as disclosed at col. 5 line 30 to col. 6, line 35, and that two-photon sensitivity of cyanine dyes is disclosed at col. 12, lines 48-51. Applicants assume that the Examiner is referring to the example in paragraph "(4)" at column 6, lines 29 to 35 of Swainson et al, which discloses eosin Y, since the example in paragraph "(3)" at column 6 of Swainson et al does not disclose eosin Y.

The Examiner argues that it would have been obvious to modify the process of Farid et al in the Examples using the oxonol dye PS 31 by using a two-photon exposure process with a Ti:Sapphire laser attuned to a wavelength of 900 nm, which is near the two-photon absorption maximum of about 906 nm, taught by Harada et al. The Examiner states that it would have been obvious to do so to increase the resolution of the imaging process as discussed by Harada et al. The Examiner further states that there would be a reasonable expectation of exciting the two-photon polymerization based upon the teachings of Swainson et al, which show this for cyanine and xanthene dyes, and which show that establishing a good starting point for a two-photon system is a compound having a single-photon response, which is established for the oxonol dye PS 31 by Farid et al.

Thus, the Examiner still appears to be arguing that in view of Swainson et al, it would be obvious to subject any dye which is known to have a single-photon response to a two-photon absorption. The Examiner further reasons that since Swainson et al disclose a two-photon absorption of the xanthene dye eosin Y, and since Farid et al disclose that oxonol dyes and xanthene dyes can be used interchangeably, it would be obvious that the oxonol dyes of Farid et al can be subjected to two-photon absorption, especially since Harada et al disclose a suitable apparatus that can be used for the two-photon absorption.

In response, applicants again submit that there is no teaching or suggestion in Farid et al, Harada et al or Swainson et al that an oxonol dye is a non-resonant two-photon absorbing material and that it could be irradiated to induce a non-resonant two-photon absorption.

Farid et al do not disclose or suggest a non-resonant two-photon absorption of any kind, and merely disclose a conventional one-photon reaction. Harada et al disclose the curing of a

photopolymerizable composition by a multiple photon absorption phenomenon, but no do not disclose or suggest a method of inducing a non-resonant two-photon absorptions by irradiating an oxonol dye to induce a non-resonant two-photon absorption.

The Swainson et al patent discloses a simultaneous multiphoton absorption for the xanthene dye sensitizer eosin Y. This system is based on a non-resonant two-photon absorption. The discussion of eosin Y in Swainson et al appears under the column 5 heading “SIMULTANEOUS MULTIPHOTON ABSORPTION SYSTEMS”, and the column 5 subheading “Class I Group 2”.

Swainson et al also disclose that cyanine dyes are subjected to a stepwise multiphoton absorption, which is not a non-resonant two-photon absorption. Thus, the discussion of cyanine dyes in Swainson et al at column 12, lines 48 to 51 appears under the subheading “Class II Group 3”, which appears under the heading at column 10 of “STEP-WISE MULTIPHOTON ABSORPTION SYSTEMS.” Since cyanine dyes are classified, according to a higher notion, as polymethine dyes just like oxonol dyes, applicants submit that it would be reasonable for one of ordinary skill in the art, in view of the information disclosed by Swainson et al, to assume that oxonol dyes could be subjected to a stepwise multiphoton absorption process in a similar manner as cyanine dyes.

Applicants submit that the disclosure in Swainson et al that the cyanine dyes are subject to a stepwise multiphoton absorption, and the lack of a disclosure in Swainson et al that the cyanine dyes are subjected to a simultaneous two-photon absorption, teach away from subjecting the oxonol dyes to a simultaneous two-photon absorption, that is, to a non-resonant two-photon absorption as set forth in claim 16. Accordingly, applicants submit that one of ordinary skill in

the art would not have been led to combining Swainson et al with the other cited documents, and that one of ordinary skill in the art would not have been led to the subject matter of claims 16 and 21 from such a combination since there is no teaching or suggestion that an oxonol dye is a non-resonant two-photon absorbing material that can be irradiated to induce a non-resonant two-photon absorption.

Thus, the Farid et al, Harada et al and Swainson et al patents do not disclose or suggest that an oxonol dye is a non-resonant two-photon absorbing material, and that it can be irradiated to induce a non-resonant two-photon absorption.

In response to the above arguments, the Examiner states in the Office Action that because "all compounds inherently will have a two-photon cross section (the probability of a two-photon absorption)," there is a reasonable expectation that a two-photon absorption will occur with the oxonol compound PS-31 of Farid et al. The Examiner states that his position is supported by Swainson et al '861 and Penzkofer et al, who discuss the use of cyanine dyes in two-photon processes. The Penzkofer et al article is discussed in a second rejection of the claims that is discussed below. The Examiner states that the motivation to use a two-photon process comes from Harada et al '032 and Swainson et al '861, who teach the increased resolution and ability to write three dimensional structures.

In reply, applicants submit that the Examiner's position that all compounds inherently will have a two-photon cross section is not correct.

Two-photon absorption does not necessarily occur simply because one-photon absorption occurs. At least, whether a compound will absorb two photons efficiently (i.e. >1,000 GM, particularly >10,000 GM) or not is unpredictable, and will become known for the first time only

after the compound is actually synthesized and evaluated. A compound absorbing two photons with $>1,000$ GM, particularly $>10,000$ GM is rarely found. Therefore, applicants submit that the high degree of efficiency obtained by the oxonol dyes set forth in the present claims further supports the patentability of the present invention.

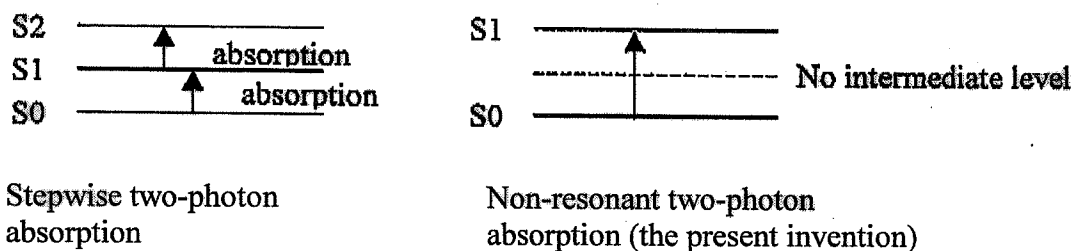
In the Advisory Action of April 30, 2007, the Examiner stated that applicants' analysis of the meaning of "simultaneous" is flawed, and provided his own analysis of the meaning of this term. The Examiner asserted in the Advisory Action that there would be a reasonable expectation of success from the combined teachings of the prior art.

The Examiner's position in the Advisory Action is not correct.

The "stepwise" absorption as stated by the Examiner is not the two-photon absorption claimed in the present application. These are totally different from each other.

In the case of a stepwise absorption, the compound is excited by a light at the wavelength in which one-photon absorption occurs, and therefore the light cannot reach the inside of the medium and a three-dimensional recording is not available. On the other hand, a two-photon absorption has no intermediate energy level. Two-photon absorption occurs by absorbing a light at the wavelength in which one-photon absorption does not occur, and, therefore, three-dimensional recording is available.

Applicants illustrate the difference between a "stepwise" absorption and the two-photon absorption of the present invention as follows:



Applicants also attach a sheet explaining a two-photon absorption.

Further, with respect to Swainson et al, applicants point out that the Examiner does not address applicants' arguments set forth above that Swainson et al do not disclose that cyanine dyes are subjected to a simultaneous two-photon absorption, but to a step-wise multiphoton absorption, do not teach or suggest that an oxonol dye is a non-resonant two-photon absorbing material that can be irradiated to reduce a non-resonant two-photon absorption, and teach away from subjecting oxonol dyes to a simultaneous two-photon absorption. Similarly, the Examiner has not addressed applicants' arguments relating to Harada et al or Penzkofer et al.

Applicants point out further that Farid et al do not disclose the oxonol dyes of formula (3) of the present application, which is recited in dependent claim 21, and which provides a further basis of patentability over the cited documents.

In view of the above, applicants submit that the cited documents do not disclose or render obvious the subject matter of the present claims and, accordingly, request withdrawal of this rejection.

Claims 16 and 21 have been rejected under 35 U.S.C. § 103(a) as obvious over Farid et al in view of Harada et al, Swainson et al and further in view of the Penzkofer et al article.

Applicants submit that the cited documents do not disclose or render obvious the subject matter of the present claims and, accordingly, request withdrawal of this rejection.

The Examiner cites the Penzkofer et al article for teaching a two-photon absorption of the trimethine dyes HMICI and PYC. The Examiner states that the PYC dye contains ketone-containing terminal moieties which are similar to those of an oxonol dye. The Examiner, therefore, believes that since Penzkofer et al disclose that ketone-containing terminal moieties can be used in two-photon absorption, this suggests that oxonol dyes can be used in two-photon absorption.

In addition, the Examiner states that the Penzkofer et al article discloses two-photon absorption dynamics of organic dye solutions. The Examiner states that this further supports the position that the oxonol dye PS 31 of Farid et al will have an appreciable two-photon absorption cross-section sufficient to cause two-photon polymerization.

In response, applicants again submit that the Examiner's analysis of Penzkofer et al is not correct and the teachings of Penzkofer et al do not disclose or suggest that oxonol dyes can be subject to a non-resonant two-photon absorption.

In particular, the Examiner's understanding that the dye PYC subjected to two-photon absorption contains a ketone-containing terminal moiety and thus, oxonol dyes can also be used for two-photon absorption, has no chemical basis at all.

The chemical feature of dye PYC lies in the fact that it is a cyanine dye having a cyanine chromogenic group (a conjugate system comprising plural repetitions of a double bond and a single bond with a positive charge), whereby the ketone moiety located at the terminal of dye PYC is directly associated with the cyanine chromogenic group, which characterizes the

chemical properties of dye PYC, but the ketone moiety in dye PYC is a simple substituent that does not contribute to its chemical properties.

On the other hand, the chemical characteristics of oxonol dyes are derived from the structure comprising plural repetitions of a double bond and a single bond together with oxygen atoms located at both ends of the repetitions and having a negative charge, whereby the ketone moiety is directly associated with the conjugate system, thus characterizing its chemical characteristics.

As has been described in detail above, the two kinds of ketone moiety, though they appear structurally similar to each other, play completely different roles, whereby the ketone moiety in dye PYC does not characterize its chemical characteristics, while the ketone moiety in oxonol dyes is essential for the development of their chemical characteristics.

In other words, it is unreasonable from a chemical viewpoint to expect an effect similar to that in the cited Penzkofer et al reference for a compound (oxonol dye) which is completely different in electronic property from the compound in the Penzkofer et al article (dye PYC) only for the reason that a ketone moiety is contained somewhere in the molecular structure of both compounds.

Further, the two-photon absorption cross-section for the two cyanine dyes HMICI and PYC disclosed in Penzkofer et al, are $(2 \pm 0.2) \times 10^{-49} \text{ cm}^4 \cdot \text{s}$ and $(1.8 \pm 0.2) \times 10^{-49} \text{ cm}^4 \cdot \text{s}$, respectively, according to Table 1, at page 333 of Penzkofer et al. Since 1 GM is defined to be $1 \times 10^{-50} \text{ cm}^4 \cdot \text{s}$, the two-photon absorption cross-sections of these compounds are roughly 20 GM.

On the other hand, the two-photon absorption cross-sections of the compounds falling within the scope of the present claims are far larger than those of the cyanine dyes in Penzkofer et al in orders. Thus, the present invention exhibits an effect far exceeding any predictable degree from Penzkofer et al. Applicants point out that among the exemplary oxonol compounds disclosed in the present specification, even the compound having the smallest two-photon absorption cross-section, namely, compound D-192, has an area of 1,200 GM, which far exceeds the roughly 20 GM cross-sections of the two cyanine dyes of Penzkofer et al. See Table 1 at pages 77 to 78 of the present specification.

The Examiner has not responded to any of the above arguments.

Applicants again point out that at least, whether a compound will absorb two photons efficiently (i.e. >1,000 GM, particularly >10,000 GM) or not is unpredictable and will become known for the first time only after the compound is actually synthesized and evaluated. A compound absorbing two photons with >1,000 GM, particularly >10,000 GM is rarely found. Therefore, applicants submit that the high degree of efficiency obtained by the oxonol dyes set forth in the present claims further supports the patentability of the present invention.

In view of the above, applicants submit that the cited documents do not disclose or render obvious the subject matter of the present claims and, accordingly, request withdrawal of this rejection.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

RESPONSE UNDER 37 C.F.R. § 1.111
Application No.: 10/678,301

Attorney Docket No.: Q77851

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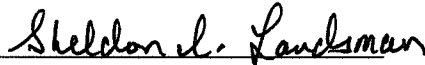
Respectfully submitted,

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

WASHINGTON DC SUGHRUE/265550

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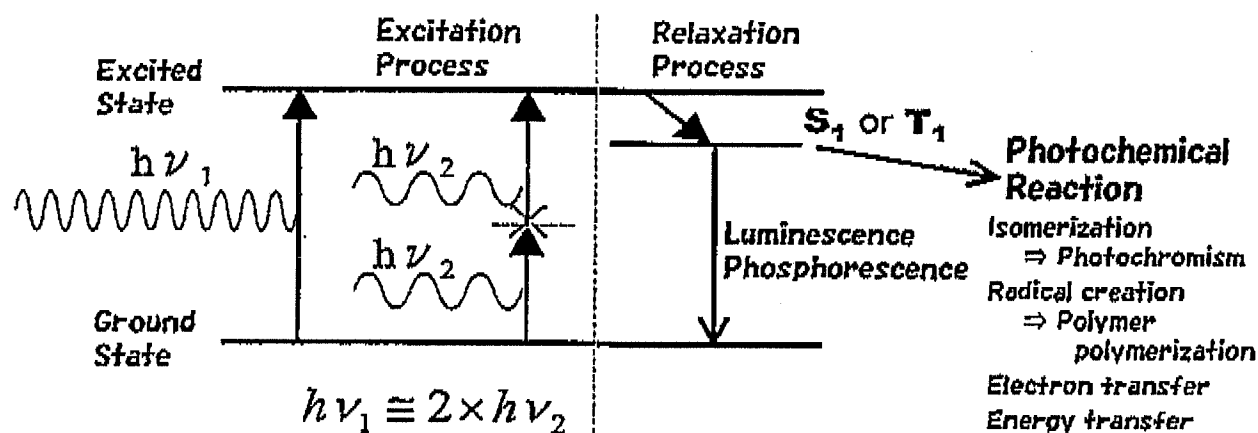

Sheldon I. Landsman
Registration No. 25,430

Date: October 30, 2007

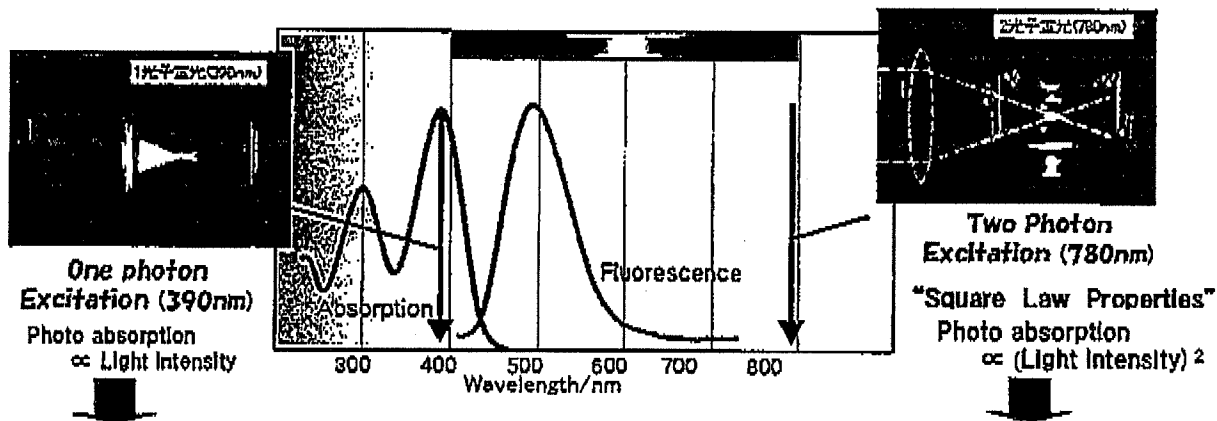
What is Two Photon Absorption?

Low Energy

A molecule simultaneously absorbs two photons.



Properties of Two Photon Absorption



Light is absorbed and attenuated at any point along the light path.

- 1) Occurs at the wavelength where OPA does not occur.
- 2) Occurs only at the focus point inside the material.

Space-Selective
Excited state